XXI.—*Notulæ Lichenologicæ.* No. XX.

By the Rev. W. A. Leighton, B.A., F.L.S.

Every lichenist is unfortunately well aware of the great difficulty of preserving specimens of lichens which grow on the earth. Too frequently he finds, on consulting his herbarium, that the earth on which such lichens grew has become dry and crumbled into dust, involving in such disintegration the destruction of the lichen itself, especially when this happens to possess a crustaceous thallus. To remedy this a solution of gum arabic has been sometimes used, but with partially satisfactory results only, inasmuch as the mucilage does not penetrate the earth, but only conglomerates its surface. An effective preparation appears to have been discovered by M. J. M. Norman, of Trömso, Norway. It consists of a solution of isinglass in spirits of wine, such as is used in the preparation of English adhesive plaster, which a chemist informs me is better known as "Prout's plaster." This composition, when liquefied in a vessel plunged into water of the temperature of 25°–30° C., is greedily imbibed by the earth on which the lichen grows, and becomes inspissated into a solid gelatine at a temperature below 15°. The solution may be applied by a camel's-hair pencil until the earth becomes saturated; but care should be taken that the lichen itself be not moistened with it, for otherwise it would become discoloured. When the surface has become dry, the specimen may be submitted to moderate pressure, which, after some days, produces the requisite hardness and tenacity. The favourable experience of some years encourages M. Norman to recommend this preparation to his fellow lichenists.

XXII.—*On the* Spongiæ ciliatæ *as* Infusoria flagellata; *or Observations on the Structure, Animality, and Relationship of* Leucosolenia botryoides, *Bowerbank**.

By H. James-Clark, A.B., B.S., Professor of Natural History in the Agricultural College of Pennsylvania†.

[Plates V., VI., VII.]

I have been engaged like others, for some time past, in endeavouring to clear up the doubt which prevails in the scien-

* A sketch of the contents of this memoir has already been published in the 'Proceedings of the Boston Society' for June 20, 1866; the 'American Journal of Science' for November 1866, and in the 'Annals' for January 1867.

† From a separate impression from the 'Memoirs read before the Boston Society of Natural History,' vol. i. part 3; communicated by the author.

tific community in regard to the nature of the Sponge. The question has been, is it an animal or is it a plant? Bowerbank, the highest classificatory authority upon this subject, for a long term of years held that it was an animal; but his *bases* for this theory were such that they did not appear to offer a satisfactory means of finally deciding the dispute. The latter remark applies with equal force to the investigations of Lieberkühn. Of later years Carter has made some special investigations in reference to this subject, and in fact he has been the first to present anything like decisive proofs of the animality of the Sponge. A few words quoted from his paper, which he published in the 'Annals and Magazine of Natural History' for April 1857, vol. xx. p. 30, will suffice to show to what extent he has carried his observations. Speaking of the "monociliated sponge-cells of the ampullaceous sac," which, he says, was set free by the disintegration of the whole mass of the sponge, he remarks that "particles .... were thrown [by the flagellum] almost point-blank on its surface, and rapidly passed into the interior." Strangely enough, though, as it seems to me now, he does not look upon the intussusception of the particles as a genuine process of swallowing, like that which obtains among the ciliated Infusoria, but describes it in several places, when speaking of the various kinds of sponge-cells, as an enveloping of the food after the manner of *Amœba*. It is plain, therefore, that he does not believe that the "sponge-cells" are endowed with a *mouth*; and moreover, if I am not mistaken, he attributes to any part of the "cell" the faculty of engulfing food. This interpretation, therefore, would exclude the Sponge from the list of Flagellata, notwithstanding the presence of the *flagellum*. That, however, does not weaken the proof as to the animality of this organism, but merely leaves it (as Mr. Carter believes it to be) in the most intimate alliance with the naked Rhizopoda; and, as if to confirm this conclusion, the same authority adds, "These monociliated sponge-cells present the contracting vesicle* in great activity, but also in variable plurality." I believe, however, that the "variable plurality" of the contracting vesicles does not alone belong to the Rhizopoda, but, as I shall show hereafter†, that it is also to be observed among the true Flagellata; and I would remark, moreover, that when we consider the close relationship (which I hope to prove in this paper) of the Sponge to the other flagellate monad-like Infusoria, which undoubtedly

* Already noticed by him, in 1847, in the Trans. Bombay Med. and Phys. Soc. (abstract in Ann. & Mag. Nat. Hist. 1848).

† *Salpingœca marinus*, n. sp., § 8, and *S. amphoridium*, n. sp., § 9.

have a definite oral aperture, we must, if on no other grounds, conclude that it also possesses a true mouth.

Still there would appear to be some who doubt whether, after all, the Sponges are really animals instead of plants, and moreover seem to insist that they are neither the one nor the other, but form with other Infusorians (such as *Volvox*, *Gonium*, *Pandorina*, *Euglena*, and other Conferva-like bodies) a group by themselves, standing intermediate to, and partaking of the nature of, both animals and plants. This is the group which has been called Phytozoa, *i. e.* plant-animals.

In the midst of this halting decision, I have been for some years past working upon a class of Infusoria the knowledge of whose structure fully prepared me not only to recognize the animal nature of the Sponge, but also enabled me to determine to what group of Infusoria it belongs. Such a decision, therefore, does not leave any trace of doubt in my mind as to the strictly animal nature of the Sponges. The whole question in dispute hinges upon the determination as to the animal or vegetable nature of the Monad-like or so-called Flagellate Infusoria. And here, again, I would say that it has fallen to my lot to decide, for the first time, that one of the smallest of the known Infusoria, the Monad (*Monas termo*, Ehr.?) is an animal. If, now, we can prove this point, the way is perfectly clear through the intermediate forms which lie between the Monad and the Sponge.

Commencing, then, with what I believe to be the *Monas termo* of Ehrenberg, I shall proceed to describe in detail a series of forms (several of which are new, both generically and specifically) which stand in the closest relationship among the lowest embodiments of infusorial life, embracing among them, as I hope to show, the true ciliated Sponges, and which, notwithstanding, lead in unobstructed although varied courses * to the more elevated kinds of Protozoa, the true Infusoria ciliata.

§ 1. *Monas termo*, Ehr. Pl. V. figs. 1, 2, 3, 4.

Upon a slight acquaintance with this infusorian, one would be strongly inclined to identify it with the younger stages of *Anthophysa Müller*i, Bory (fig. 49); but a more searching investigation reveals such a number of characters in each which are not to be found in the other, that one need not have any hesitation whatever in setting them down as totally diverse organisms. In fact *Monas* belongs to the uniciliate Flagellata, whilst the other genus just mentioned is a biciliate heteronematous form.

Monas lives in two diverse conditions, of which one is a

* See the preliminary remarks upon *Anthophysa*, § 11.

fixed state (fig. 3), and the other a free and motile stage (figs. 1, 2, 4). During its sedentary life, it may be found in great abundance on the old stems of *Myriophyllum*, *Potamogeton*, *Ceratophyllum*, and other aquatic phænogamous plants which inhabit quiet waters, and are more or less thickly covered by a floccose overgrowth of various minute Confervæ, Diatomaceæ, &c. In its free state it swims with either a sort of hitching, wriggling motion, or, gliding along smoothly, revolves at an inconstant but never rapid rate upon its longer axis, of which the flagellum (fig. 2 *fl*), which always precedes it, may be said to be a prolongation. This is the condition in which it is most frequently to be found after it has been kept a few days in an aquarium. It then gathers in swarms about decomposing matter, and thus affords frequent opportunity of seeing its mode of collecting and swallowing its food.

The *form* of the body in a fixed state (fig. 3) may be compared to a flattened heart, of which one summit is prolonged into a broad, conical, transparent beak (*lp*), and at the opposite end the apex is attached to a slender, flexible pedicel (*pd*), which frequently is equal in length to four or five times the antero-posterior diameter of the body. In a free condition (fig. 2) the posterior end is rounded and about as broad as the front, but still it presents the same lateral flattening as the fixed form. The prevailing colour is a faint olive or yellowish green.

The *flagellum* (*fl*) is the only cilium-like organ which this creature possesses. It is attached to the front, close to the proximal side of the conical beak (*lp*), and consequently lies in the axial line of the body. In a quiet state, which it most frequently assumes during the fixed condition, it appears like an arcuate bristle, and extends from near its base to its apex in one uniform, slightly but distinctly curved line, and terminates without any very sensible diminution in thickness. The plane of its curve is in direct extension of the plane of the greater diameter of the body, and at the same time passes through the conical beak. During natation the flagellum takes precedence and vibrates with an undulating whirling motion which is most especially observable at its tip, and produces by this mode of propulsion the peculiar rolling of the body which at times lends so much grace to its movements as it glides from place to place. During the fixed state of the body the chief design of the movements of the flagellum is the prehension of food; and this is accomplished by a peculiar abrupt deflection of the end of this organ towards the *front*, by means of which particles of various kinds are made to impinge upon the region immediately at the proximal side of the

base of the broad conical beak—a point at which, as will be seen presently, the mouth is situated.

The *mouth* (figs. 3, 4, *m*) lies between the base of the flagellum (*fl*) and the beak, or *lip* (*lp*), as I shall hereafter designate it, from its obvious office, presently to be described. A plane, therefore, drawn through the lip and the base of the flagellum, would also strike the mouth, and moreover form a continuation of that of the greater diameter of the body. This aperture is not visible during its closed state; but its presence has been often and unmistakeably determined by seeing the masses of food enter invariably at the point designated above. As already stated, particles are thrown with a sudden jerk, precisely as is done by *Anthophysa Müllerí*, Bory (figs. 50, 51), and apparently with great precision, directly against the mouth (fig. 4, *m*). If acceptable for food, the flagellum presses its base down upon the morsel, and at the same time the lip is thrown back (fig. 4, *lp*) so as to disclose the mouth, and then bent over the particle as it sinks into the latter. When the lip has obtained a fair hold upon the food, the flagellum withdraws from its incumbent position and returns to its former rigid, watchful condition (fig. 4, *fl*). The process of deglutition is then carried on by the help of the lip alone, which expands laterally until it completely overlies the particle. All this is done quite rapidly, in a few seconds; and then the food glides quickly into the depths of the body, and is enveloped in a digestive vacuole (*d*), whilst the lip assumes its usual conical shape and proportions.

The *contractile vesicle* (figs. 2, 3, 4, *cv*) is a much larger and far more active organ than that of *Anthophysa* (figs. 47, 48, *cv*). If we view the body from its narrower aspect (fig. 2), when it stands so that the lip (*lp*) is nearest the eye, the contractile vesicle (*cv*) appears in profile, on the left broad side, and so close to the surface that it seems to project beyond the general outline of the body. It lies in the anterior third of the broad side just mentioned, and close to the transverse plane which separates that part which contains it from the one upon which the lip is placed. From whichever direction, therefore, one views this organ, it will be seen to stand in an asymmetrical relation to the rest; and as it is preeminently a dominant feature, it may serve, perhaps better than any other, as a starting-point in determining the obliquity of the type of this infusorian, and its perfect consonance in this respect with that of the more obviously spiral forms, such, for instance, as are exemplified by *Dysteria* (figs. 77, 78) and *Pleuronema* (figs. 75, 76). It is so large and conspicuous that its globular form may be readily seen, even through the greatest diameter of the body; and it

contracts so vigorously and abruptly, at the rate of *six times a minute*, that there seems to be a quite sensible shock over that side of the body in which it is imbedded.

The *reproductive organ* may possibly be represented by the very conspicuous, bright, highly refracting, colourless, oil-like globule (*n*), which is enclosed in a clear vesicle, and appears to be so constantly present in the depths of the posterior third of the body. Its position seems to be invariably on that side of the transverse axial plane which is opposite to that in which the contractile vesicle (*cv*) lies. Nothing further of a positive nature can be said in regard to this body; but we may conjecture that, inasmuch as it cannot well be assigned to any other office, not even to that of an eye-spot, it is in all probability an organ of reproduction.

In regard to the *stem* (fig. 3, *pd*), it may be added that, although it appears to be of the simplest nature—a mere gossamer thread as it were, it is none the less positive, as a support, than that of *Anthophysa* (figs. 47, 48, 49, *pd*), and must indeed possess a similar self-reliant power in order to keep the body in the same relative position in regard to the object to which it is attached, or to sustain it in an upright attitude at a time when the flagellum is quiet and there is consequently no other means of preventing the animal from sinking down upon the nearest fixed point.

§ 2. *Monas neglecta*, nov. sp. Pl. V. figs. 5, 5^{a}, 5^{b}, 6.

To a casual observer this species would appear to be one of the varieties of *Monas termo* of § 1; and I must confess that, under an amplification of only five hundred diameters, the mistake would be easily made, unless one had become perfectly familiar with the two by prolonged study with a much higher magnifying-power. There is, though, a physiological difference which can be observed when all others could scarcely be noted, which is this: the rate of the systole of the contractile vesicle (*cv*) of this species is double that of *Monas termo*. Like the latter it enjoys two diverse conditions of life—namely, a fixed (figs. 5, 5^{a}, 6) and a free (fig. 5^{b}) state,—frequents the same habitat, progresses with the same means and mode of locomotion, and obtains its food by similar prehensile organs, and swallows it in the same manner.

The *form* of the body is that of an oval, but terminates anteriorly in an obliquely truncate front; or, rather, one side of the front projects in the form of a low, rounded prominence, which constitutes the *lip* (*lp*). The posterior end is either broadly rounded or very bluntly pointed where the pedicel (*pd*) is attached. The colour is either greyish or there is none at all.

The *flagellum* (*fl*) has more of a sigmoid flexure than that of *Monas termo* (figs. 1–4), and about as much as that of *Anthophysa Müllerí*, Bory (figs. 47, 48, *fl*). It arises from the axial point of the front, and extends to about three times the length of the body. The plane of its curve bears the same relation to the mouth and lip as that of *Monas termo*, and it is used in the same manner as a prehensile organ to assist the lip (fig. 6, *lp*) when taking food, and for a propelling-apparatus (fig. 5^b, *fl*), as the body whirls along after it during natation.

The *mouth* (fig. 6, *m*) lies in the same relative position as that of *Monas termo*, and receives its food in precisely the same manner, and, by the assistance of the lip (*lp*), with the same degree of rapidity passes it into the body.

The *contractile vesicle* (*cv*) lies on the same side of the plane of the arcuate flagellum (*fl*) as that of *Monas termo*, and at about the same distance from the front, but in an opposite region, and directly in the antero-posterior line with the lip. It is also a more vigorous and larger organ than that of the other *Monas*; and, bulging out (fig. 5^a, *cv*) the body even more strongly during expansion, its systole takes place at double the rate (that is, *twelve times a minute*), and very abruptly.

The *pedicel* (*pd*) sometimes attains to four or five times the length of the body, but most frequently it is not more than half as long as that. It is thin and delicate, but appears to possess considerable rigidity, either in a fully extended state, or when (as appears to be the case sometimes) it is contracted into more or less abrupt curves (fig. 6, *pd*). Its apex (fig. 5^a, pd^1) is attached to the posterior end of the body, at a point which is coincident with the longitudinal axis.

§ 3. Bicosœca, nov. gen.*

Bicosœca gracilipes, nov. sp. Pl. V. figs. 34, 35.

This genus might be compared to a *Monas* seated in a calyx, and upon a highly muscular, contractile stem.

Bicosœca gracilipes is a marine form, and has thus far been found, although in considerable numbers, only upon *Sertularia cupressina*, Linn. It is an excessively minute creature, as may be readily judged by the reader upon referring to the magnifying powers which are laid down in the description of the figures. When first met with, it appeared, upon a casual observation and under a magnifying-power of only five hundred diameters, to be an elongate, naked *Monas*, which was kept in a firm position by some invisible power. It soon, however, attracted particular attention to itself by its peculiar, spasmodic

* *βίκος*, a vase; *οἰκέω*, to inhabit.

and often-repeated retrocession. Upon putting on a power of eight hundred diameters, the whole organization was brought out with sufficient clearness to satisfy one upon every point. For the purposes of illustration, however, it was thought best to increase the magnifying-power to a still greater extent; and we have, therefore, drawn one figure (fig. 34) to represent this infusorian as it appears when seen under an amplification of about fifteen hundred diameters.

This animal has never been found in a free state, or in any other than that which is represented in these two figures (figs. 34, 35). It has an elongate oval body, which is enclosed in a deep vasiform, pedicellated calyx (*c*), to whose bottom it is attached by a slender, colourless, contractile ligament (*r*). It usually rests about halfway between the top and bottom of the calyx, but is frequently jerked to the bottom (fig. 35) of the vase (*c*) by means of the ligament just mentioned. The anterior end is truncate, and prolonged into two prehensile organs, one of which is a *flagellum* (*fl*), and the other a *lip* (*lp*) similar in position and function to that of the *Monas* described in the previous section. The generally prevailing fuscous tint is interrupted by a transparent colourless streak (r^1), which extends from the laterally posited base of the flagellum (*fl*) to the posterior end of the body, where it seems to be prolonged into the contractile ligament (*r*). It is not a band, however, but a sharply defined furrow, of considerable depth. At the anterior end it is sunk so deeply that it borders closely upon the base of the flagellum, and from that point it gradually shallows until it nearly disappears at the point of junction of the body with the contractile ligament.

We are thus reminded of those heteronematous Flagellata, like *Anisonema* (figs. 65–69), whose bodies are so conspicuously sulcated in a longitudinal direction; and the apparent continuity of the retractor ligament (fig. 34, *r*) with this furrow (r^1) heightens the impression, by its resemblance to the highly muscular trailing lash (figs. 65–69, fl^2) of that genus. One could hardly be accused of unduly straining a point in homology if he were to regard the furrow (fig. 34, r^1) in question as merely a greatly prolonged ostial notch, and the retractor (*r*) as a trailing lash, which originated at the greatest possible distance from the other, its proboscidal companion (*fl*).

The *lip* (*lp*) is a more prominent organ than that of *Monas*. It has a conical shape, and is about twice as long as its greatest breadth. It is so hyaline as to readily escape notice until it is fully recognized. It is situated at the edge of the truncate front opposite to that from which the flagellum arises, and therefore leaves a considerable space between the latter and

itself. Within this broad space the simple mouth (*m*) is situated.

The *flagellum* (*fl*) is the most active of the prehensile organs, and the only vibratory filamentous body which this animalcule possesses. In length it is about three times that of the body, or a little more, and projects far beyond the rim of the vase (*c*). It is a curious fact that while in *Monas* and *Anthophysa* the lip and flagellum lie closely together, they stand far apart in *Bicosœca*. The flagellum is not an undulatory, vibrating organ, in the common sense of the term, but usually supports itself in a rigid condition, except at the tip, which is kept in nearly constant motion, incurvating with frequent jerks, and tossing floating particles toward the mouth. Its distal two-thirds is quite strongly curved, but not so much as to be absolutely falcate; and at its basal third it is moderately arcuated in the opposite direction, so that the whole flagellum has a slightly sigmoid flexure. The plane of this curve is such as to strike the mouth and lip when carried out in that direction. The diameter of this organ is about equal from tip to base, excepting a slight thickening at the latter point. The only times that the flagellum abandons its rigid deportment are either when it is assisting the lip to seize the food, or during the spasmodic retrocession of the body. In the latter case it is abruptly retracted and coiled (fig. 35, *fl*) transversely within the calyx (*c*) close down to the truncate front of the body. When the latter slowly pushes forward from the bottom of its dormitory, the flagellum as deliberately uncoils, and at first vibrates with a rapid wriggle, but finally assumes its former sigmoid curve and rigid deportment.

The *mouth* (*m*), as has already been mentioned incidentally, lies in the middle of the truncate front, and consequently faces toward the aperture of the calyx (*c*). Food is brought to it by means of the flagellum (*fl*); and the latter and the lip (*lp*) force it into the oral aperture exactly in the same way as has been described in regard to *Monas*.

The *contractile vesicle* (*cv*) is a single globular organ, which lies on the corresponding side of the body with that of *Monas*, and just in front of the middle. In full diastole its diameter equals one-third of that of the body. Both the systole and diastole are very slow.

The *calyx* (*c*) is about twice as long as the body which it encloses, and between four and five times its own average diameter. It has the form of a very deep slender urn, with a rounded bottom, slightly contracted waist, and a very delicate, scarcely reverted, truncate rim. It is so hyaline and faint that it almost defies any magnifying-power below that of eight

hundred diameters. The pedicel (*pd*) which supports it is at least twice as long, of uniform diameter throughout, and very slender, in fact not much thicker than the flagellum. It is attached (*pd*[1]) to the bottom of the calyx, exactly opposite to the point from which the contractile ligament (*r*) arises; but, unlike the latter, it appears to be totally incapable of contraction.

[To be continued.]

BIBLIOGRAPHICAL NOTICES.

The Natural History of the Tineina. By H. T. Stainton. Vol. X. 8vo. London: Van Voorst. 1867.

Before saying anything upon the contents of the present volume, we must congratulate Mr. Stainton upon having reached the first halting-place in his laborious undertaking. He has every reason to glance back with satisfaction over the ten beautiful volumes which he has produced in the last thirteen years; and although he himself speaks, in a somewhat deprecatory tone, of his having failed to keep up to his original estimate of two volumes annually, we fancy that most of his readers will think that he has accomplished a gigantic amount of work.

The present volume contains the Natural History of twenty-four species of the genus *Gelechia*; so that, with the contents of the ninth volume, Mr. Stainton has illustrated forty-eight species of that difficult group. But such is the progress of discovery now-a-days that it seems difficult for an author even to keep pace with it. These forty-eight species are scarcely more than a fifth of the known European members of the genus, which now, according to Mr. Stainton's list of them, amount to 231; but of these the transformations of only about 100 are known, so that in reality we have in these two volumes the history of nearly half those species whose life has been thoroughly investigated.

In comparing the habits of these larvæ with those of the nearly allied genus *Depressaria*, in which the history of fifty-two out of eighty-one species was known in 1861, Mr. Stainton arrives at some curious results with regard to what may be called their botanical distribution. Thus, whilst nearly half the known larvæ of *Depressaria* feed upon Umbelliferous plants, no single *Gelechia* is known to derive its nourishment from that order; the Compositæ, which nourish fourteen *Depressariæ* (out of fifty-two), have only ten *Gelechiæ* (out of 100) attached to them; the Leguminosæ are patronized by about twice the number of the latter in proportion to the former genus; and the Caryophyllaceæ, which are quite free from the attacks of *Depressariæ*, are known to harbour fourteen species of *Gelechia*.

It will be unnecessary for us to follow Mr. Stainton through his elaborate historical notice of the genus, or the histories of the twenty-four species here set forth; his mode of treatment of his subject must